Comparison Concentrations for Radionuclides in Fish in the Clinch River
Assuming Ingestion of 27 kilograms of Fish Caught in the Clinch River Per Year
October 12, 2020

The following table was developed using radionuclides that EMDF Performance Assessment Table B.5 indicates have an average activity concentration in waste greater than 1 pCi/gram decayed to CY 2047. To this list of radionuclides, fission products (Cd-113m, Cs-135, Pd-107, Se-79, Sm-151, Sn-11m, Sn-126, and Zr-93) were added because the EMDF Performance Assessment indicated it would be determined in the future whether significant activities of these radionuclides are in the waste. Cs-134 and Ru-106 were added because of high activities of these shorter half-life radionuclides in the CERCLA remedial investigation and feasibility study evaluating transporting waste offsite. Alpha activity, beta activity, Be-7, Co-60, and Th-228 were added because fish were analyzed at CRK-16 at least once for these between CY2000 and CY2019. This analysis was done using the Preliminary Remediation Goals for Radionuclides (PRG) calculator at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search. The analysis was run using 1X10-5 excess cancer risk and a fish ingestion of 27 kg/year. Otherwise default parameters were used. The analysis was run in a manner that provides output of the radionuclides and progeny throughout the chain without assuming secular equilibrium. Radionuclides that did not have slope factors are represented with a dash (-) in the Food Ingestion Slope Factor column and corresponding cells in that row. The PRG values in the table below represent the PRG related to the risk level as if no other carcinogenic constituents (e.g. radionuclides) are present. If multiple carcinogens are present, then the cumulative excess cancer risk needs to be determined. Non-carcingenic risk from consuming fish containing uranium was added to the end of the table using the calculator at at https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search and a fish ingestion of 27 kg per year.

Fish Sampling for Radionuclides in the Clinch River at Stations (CRK16, CRK32, and CRK 70) identified in the Oak Ridge Reservation (ORR) Annual Site Evaluation Report (ASER)						
Isotope	Food Ingestion Slope Factor (risk/pCi)	Fish Consumption PRG* TR=1.0E-05 (pCi/g)	Fish Consumption PRG TR=1.0E-05 (mg/kg)	Fish Consumption PRG** TR=1.0E-04 (pCi/g)	Frequency Radionuclide analyzed at CRK-16*** from CY 2000 to CY 2019	Location with Radionuclide Measured Above Detection Limit Reported in 2019 ORR ASER
Ac-225	2.72E-10	0.053	9.07E-13	0.525	Not Analyzed	
Ac-227	2.45E-10	0.058	8.05E-10	0.582	Not Analyzed	
Ac-228	2.73E-12	5.2	2.34E-12	52	Not Analyzed	
Alpha Activity	-****	-	-	-	2000-2019	CRK-16, CRK-70
Am-241	1.34E-10	0.11	3.12E-08	1.1	2019 only	CRK-16
Am-243	1.34E-10	0.11	5.34E-07	1.1	Not Analyzed	
At-217	-	-	-	-	-	-
At-218	-	-	-	-	-	-
At-219	-	-	-	-	-	-
Ba-137m	-	-	-	-	-	-
Beta Activity	-	-	-	-	2000-2019	CRK-16, CRK-32, CRK-70
Be-7	1.21E-13	118	3.36E-10	1,180	2003-2019	
Bi-210	1.30E-11	1.1	8.85E-12	11	Not Analyzed	
Bi-211	-	-	-	-	-	-
Bi-212	1.01E-12	14	9.66E-13	141	Not Analyzed	
Bi-213	7.18E-13	20	1.03E-12	199	Not Analyzed	

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Bi-214	2.65E-13	54	1.22E-12	538	Not Analyzed	
Bi-215	-	-	-	-	-	-
C-14	2.00E-12	7.1	1.60E-06	71	Not Analyzed	
Cd-113	2.88E-11	0.495	1.21E+06	5.0	Not Analyzed	
Cd-113m	3.67E-11	0.389	1.73E-09	3.9	Not Analyzed	
Cm-243	1.24E-10	0.115	2.29E-09	1.2	2019 only	
Cm-244	1.08E-10	0.132	1.63E-09	1.3	2019 only	
Cm-246	1.33E-10	0.107	3.52E-07	1.1	Not Analyzed	
Cs-134	5.18E-11	0.276	2.13E-10	2.8	Not Analyzed	
Cs-135	7.81E-12	1.8	1.59E-03	18	Not Analyzed	
Cs-137	3.74E-11	0.382	4.42E-09	3.8	2000-2003 and 2019	
Co-60	2.23E-11	0.64	5.66E-10	6.4	2000	
Eu-152	8.33E-12	1.7	9.88E-09	17	Not Analyzed	
Eu-154	1.42E-11	1.0	3.73E-09	10	Not Analyzed	
Fr-221	-	-	-	-	-	-
Fr-223	1.01E-11	1.4	3.69E-14	14	Not Analyzed	
Gd-152	3.85E-11	0.371	1.70E+04	3.7	Not Analyzed	
H-3 (Tritium)	1.44E-13	99	1.03E-08	991	2000-2019	CRK-16, CRK-32, CRK-70
Hg-206	-	-	-	-	-	-
I-129	1.97E-10	0.073	4.11E-04	0.725	Not Analyzed	
K-40	3.42E-11	0.417	5.85E-02	4.2	2000-2019	CRK-16, CRK-32, CRK-70
Nb-93m	1.22E-12	12	4.92E-08	117	Not Analyzed	
Nd-144	3.92E-11	0.364	3.36E+05	3.6	Not Analyzed	
Ni-59	3.85E-13	37	6.19E-04	371	Not Analyzed	
Ni-63	9.69E-13	15	2.60E-07	147	Not Analyzed	
Np-237	8.29E-11	0.172	2.45E-04	1.7	2019 only	CRK-16, CRK-32
Np-239	7.62E-12	1.87	8.09E-12	19	Not Analyzed	
Pa-231	2.26E-10	0.063	1.34E-06	0.632	Not Analyzed	
Pa-233	8.95E-12	1.6	7.68E-11	16	Not Analyzed	
Pa-234	3.00E-12	4.8	2.38E-12	48	Not Analyzed	
Pa-234m	-	-	-	-	-	-
Pb-209	3.49E-13	41	8.90E-12	409	Not Analyzed	
Pb-210	1.18E-09	0.012	1.58E-10	0.121	Not Analyzed	
Pb-211	5.81E-13	25	9.97E-13	246	Not Analyzed	
Pb-212	3.57E-11	0.400	2.88E-13	4.0	Not Analyzed	
Pb-214	4.85E-13	29	9.00E-13	294	Not Analyzed	
Pd-107	3.81E-13	37	7.29E-02	374	Not Analyzed	
Po-210	2.25E-09	0.006	1.41E-12	0.063	Not Analyzed	
Po-211	-	-	-	-	-	-

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Po-212	-	-	-	-	-	-
Po-213	-	-	-	-	-	-
Po-214	-	-	-	-	-	-
Po-215	-	-	-	-	-	-
Po-216	-	-	-	-	-	-
Po-218	-	-	-	-	-	-
Pu-238	1.69E-10	0.084	4.92E-09	0.842	2019 only	CRK-32, CRK-70
Pu-239	1.74E-10	0.082	1.32E-06	0.819	2019 only	CRK-16, CRK-70^
Pu-240	1.74E-10	0.082	3.61E-07	0.819	2019 only	CRK-16, CRK-70^
Pu-241	2.28E-12	6.3	6.05E-08	63	Not Analyzed	
Pu-242	1.66E-10	0.086	2.19E-05	0.861	Not Analyzed	
Ra-223	3.39E-10	0.042	8.24E-13	0.422	Not Analyzed	
Ra-224	2.38E-10	0.06	3.77E-13	0.599	Not Analyzed	
Ra-225	1.54E-10	0.093	2.39E-12	0.929	Not Analyzed	
Ra-226	5.14E-10	0.028	2.81E-08	0.277	Not Analyzed	
Ra-228	1.42E-09	0.01	3.68E-11	0.100	Not Analyzed	
Rh-106	-	-	-	-	-	-
Rn-218	-	-	-	-	-	-
Rn-219	-	-	-	-	-	-
Rn-220	-	-	-	-	-	-
Rn-222	-	-	-	-	-	-
Ru-106	6.11E-11	0.234	7.10E-11	2.3	Not Analyzed	
Sb-126	1.82E-11	0.786	9.38E-12	7.9	Not Analyzed	
Sb-126m	9.73E-14	147	1.89E-12	1,470	Not Analyzed	
Se-79	9.18E-12	1.6	1.01E-04	16	Not Analyzed	
Sm-148	4.11E-11	0.347	1.01E+06	3.5	Not Analyzed	
Sm-151	8.14E-13	17.5	6.67E-07	175	Not Analyzed	
Sn-121	2.22E-12	6.4	6.71E-12	64	Not Analyzed	
Sn-121m	3.44E-12	4.2	6.17E-08	42	Not Analyzed	
Sn-126	3.74E-11	0.382	3.10E-05	3.8	Not Analyzed	
Sr-89/90					2000-2002	
Sr-90	6.88E-11	0.207	1.50E-09	2.1	2003-2019	
Tc-99	4.00E-12	3.6	2.09E-04	36	Not Analyzed	
Th-227	7.03E-11	0.203	6.60E-12	2.0	Not Analyzed	
Th-228	1.48E-10	0.096	1.18E-10	0.964	2019 only	CRK-32
Th-229	2.90E-10	0.049	2.31E-07	0.491	Not Analyzed	
Th-230	1.19E-10	0.120	5.82E-06	1.2	2019 only	CRK-32
Th-231	3.22E-12	4.4	8.36E-12	44	Not Analyzed	
Th-232	1.33E-10	0.107	9.78E-01	1.1	2019 only	
Th-234	3.39E-11	0.421	1.82E-11	4.2	Not Analyzed	

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Tl-206	-	-	-	-	-	-
Tl-207	-	-	-	-	-	-
Tl-208	-	-	-	-	-	-
Tl-209	-	-	-	-	-	-
Tl-210	-	-	-	-	-	-
U-232	**3.85E-10**	**0.037**	**1.66E-09**	**0.371**	**Not Analyzed**	
U-233	**9.69E-11**	**0.147**	**1.53E-05**	**1.5**	**Not Analyzed**	
U-234	9.55E-11	0.150	2.40E-05	1.5	2019 only	CRK-16, CRK-32, CRK-70
U-235	**9.44E-11**	**0.151**	**7.01E-02**	**1.5**	**Not Analyzed**	
U-235m	**1.06E-17**	**1,340,000**	**4.37E-08**	**13,400,000**	**Not Analyzed**	
U-236	**8.99E-11**	**0.159**	**2.46E-03**	**1.6**	**Not Analyzed**	
U-237	**7.29E-12**	**2.0**	**2.40E-11**	**20**	**Not Analyzed**	
U-238	8.66E-11	0.165	4.91E-01	1.7	2019 only	CRK-16
Y-90	**2.65E-11**	**0.539**	**9.95E-13**	**5.4**	**Not Analyzed**	
Zr-93	**1.41E-12**	**10**	**4.04E-03**	**102**	**Not Analyzed**	
Noncarcinogenic Risk from Uranium^^ Clinch River with ingestion of 27 kg of fish per year						
	RfD (mg/kg-day)	**HQ=1 (mg/kg)**		**HQ=3 (mg/kg)**		
Uranium	**2.0E-04**	**0.217**		**0.651**		

* Calculated with EPA Radionuclide Preliminary Remediation Goal (PRG) calculator at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search Cancer Risk calculated based on ingestion of 27 kg of fish annually. Rationale for annual ingestion of 27 kilograms of fish per year is included in the 2018 ASER, Section 7.2.2 Fish Consumption, page 7-22. The ORR ASER uses ingestion of 27 kilogram of fish per year in the determination of dose, risk, and hazard quotients from consumption of fish from the Clinch River.

** Multiply 10-5 PRG by 10 to calculate the 10-4 PRG.

*** Fish samples for radionuclide analyses for the ORR ASER were collected at CRK-16, CRK-32, and CRK-70. Radionuclide analyses run at CRK-16 was used to represent radionuclide analyses at the 3 locations. The table includes which years analysis for each radionuclide was performed from Calendar Year (CY) 2000 to CY 2019. Rows highlighted in red had detects in CY2019. Rows identified as "Not Analyzed" did not report analysis at these locations from CY 2000 to CY 2019.

**** - Was used where the Oak Ridge National Laboratory (ORNL) Risk Assessment Information Center (RAIS) did not include slope factor for radionuclides and without a slope factor calculation of a radionuclide in fish that equates to a specific risk level is not available.

^ Reanalysis of the CRK-70 sample resulted in a lower concentration of Pu-239/240 than the original sample analysis. The reanalysis result was below the detectable concentration (2019 ASER page 7-11).

^^ Uranium hazard quotient calculated using 27 kilograms of fish per year ingestion and the EPA Regional Screening level (RSL) calculator at https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search.